

Head Tilt Posturography to Enhance Balance Control Assessment for Astronauts: A Case Study

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Background: For many years, we have used a standard clinical computerized dynamic posturography (CDP) protocol to assess recovery of integrated sensory-motor function in astronauts returning from space flight. The most reliable indications of post-flight crew performance capabilities have been obtained from the sensory organization tests (SOTs) within the CDP protocol, particularly SOTs 5 (eyes closed, surface support sway referenced) and 6 (eyes open, surface support and visual surround sway referenced), which are sensitive to changes in availability and/or utilization of vestibular cues. We have observed, however, that some astronauts exhibiting visible signs of incomplete sensory-motor recovery are able to score within clinical norms on standard SOTs 5 and 6 trials, perhaps as a result of cognitive strategies driven by their naturally competitive natures. To improve the sensitivity of the CDP protocol for assessing recovery of integrated sensory-motor function and fitness to return to duties and/or activities of daily living, we have introduced pitch plane head tilt SOT trials to our protocol. In a preliminary study of 5 short duration (~11-day missions) astronauts, we showed that they were unable to maintain balance on landing day when performing dynamic head tilt trials, despite scoring within the clinically normal range on the standard SOT trials. The present case report illustrates the advantages of including head tilt trials for assessing sensory-motor recovery in long duration crewmembers. **Methods:** Twice before launch (60 and 30 days) and thrice after landing (1, 3, and 9 days), a long duration space flight (approx. 180-day mission) crewmember performed a set of standard, head erect, clinical SOTs and a set of head tilt SOTs. The head tilt SOTs included standard SOT 2 (eyes closed, fixed support surface) and SOT 5 trials with: 1) head pitched backwards by 20° from the erect position, and 2) head pitching sinusoidally by $\pm 20^\circ$ about erect position at 0.33 Hz (synchronized to an audible tone). Performance on each 20 sec trial was quantified by the equilibrium score (EQ), a standard CDP performance measure inversely proportional to the peak A-P sway over the trial. Performance on standard clinical SOTs was compared with the performance of a normative population (n=112), while performance on the head tilt SOTs was compared to an astronaut database (n=19). Comparisons were also made between the crewmember's pre- and post-flight performances. **Results:** Before flight, the crewmember's EQ scores for the standard clinical SOTs were within the average range for scores for a normative population, and for the head tilt trials were within the average range for the astronaut population. Specifically looking at SOT 5 head erect results, the crewmember performed below the clinical norm 24 hrs following return from space flight, but recovered to the lower normal range by 72 hrs after landing, and to pre-flight performance by 9 days after landing. However, when performing the head tilt SOTs 24 hrs after landing, the crewmember lost balance during each SOT 5 static tilt trial, and all dynamic tilt trials were waived because of the crewmember's clearly disrupted sensory-motor coordination. By 72 hrs after landing, the crewmember was able to perform the static tilt trials without losing balance, but lost balance on both of the SOT 5 dynamic tilt trials attempted that day. During the final test session, 9 days after landing, the crewmember's performance on all head erect and static tilt trials had returned to pre-flight performance levels, however the crewmember's performance was still well under pre-flight performance for the SOT 2 dynamic tilt trials, and the crewmember lost balance on two of the three SOT 5 dynamic tilt trials. **Discussion:** Previous studies in our laboratory have shown that head tilt SOT trials improve the sensitivity of balance control assessment of competitive,

high performing individuals, both in ground based studies and in short duration space flight astronaut studies. This case study of a long duration astronaut supports our earlier findings and also shows evidence of mission duration effects on balance control recovery after return. The pattern of recovery appears to aptly track the re-integration of sensory-motor function, with head erect performance recovering more quickly than static head tilt performance, which, in-turn recovers more quickly than dynamic head tilt performance. This seems logical as each successive test condition presents an increasingly more complex set of sensory-motor/biomechanical conditions for identifying spatial orientation and coordinating movements. **Conclusions:** Head tilt SOT trials in combination with standard clinical SOTs provide a more sensitive posturography test protocol for assessing the balance control recovery of astronauts after return from space flight and for providing clinical advice to the crewmember and flight surgeon regarding fitness for return to duties and/or activities of daily living.